CHAPTER II.5: COST OF LUNG CANCER

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CHAPTER II.5: COST OF LUNG CANCER

This chapter contains a discussion of the methods used and results of estimating the direct medical costs incurred by lung cancer patients. It does not include information on elements such as indirect medical costs, pain and suffering, lost time of unpaid caregivers, etc. The reader is referred to Chapter I.1 for a discussion of the cost estimation methods and cost elements that are relevant to all benefits estimates. In addition, Chapter II.1 contains information regarding cancer causality, a list of known and suspected carcinogens, and information on cancer cost estimation.

The costs presented in this chapter were current in the year the chapter was written. They can be updated using inflation factors accessible by clicking on the sidebar at left.

Link to Chapters I.1 and II.1
Link to inflation factors

II.5.A Background

II.5.A.1 Description

Lung cancer is the most frequent cause of cancer death in men and women in the United States (Feld et al., 1995). There were approximately 173,000 cases of lung cancer diagnosed in 1994 in the United States and approximately 150,000 lung cancer deaths occurred in that year (NCI, 1998). The increase in overall deaths per year from 18,000 in 1950 and 125,000 in 1988 to the current level is due, in part, to a more than five-fold increase in lung cancer death rates (per 100,000) among women. This increase is likely to be due to increased smoking rates (Bennett and Plum, 1996). Lung cancer is fatal in over 88 percent of all cases (NCI, 1998).

Lung cancer is a malignancy within the lungs and may be localized or have spread to multiple sites (Bennet and Plum 1996). All types of lung cancer likely originate from a common pluripotent stem cell. There are four types of lung cancer: squamous (epidermoid), adenocarcinoma, large cell, and small cell (oat cell). The first three types are often grouped together as non-small cell lung cancer (NSCLC). These three types, which comprise 75 to 80 percent of all lung cancers, have different natural histories and respond differently than small cell lung cancer to therapies. There are also very rare types of lung cancer (with an approximate incidence of two percent) that include adenosquamous mixed tumor or mixed small cell and non-small cell histologies (Feld et al., 1995). Survival data from the National Cancer Institute (1998) and cost data from Baker et al. (1989) that are used in this chapter do not provide quantitative information for different types of lung cancer. Consequently, this chapter contains an

evaluation of all types of lung cancer in aggregate. In addition, most risk assessments that would be used in evaluating benefits do not specify the type of lung cancer. If a specific type of lung cancer is of concern, Feld et al. (1995) may be consulted for additional information regarding prognostic information and treatment; however, the quantitative data are limited.

New discoveries may, have an impact on the diagnosis and understanding of the causality of lung cancer in the future. Cytogenic abnormalities have been demonstrated in lung cancer cells including lesions in chromosome region 3p, which occurs as an early event in the biology of the tumor. Mutation of the p53 gene is the most frequently identified genetic change in human lung cancer. Activated proto-oncogenes are seen in lung cancer and may arise from point mutations in the level of expression. Some of the above changes may be used in the future for early detection of lung cancer. Screening programs in the past, using more traditional diagnostic measures, have not been successful in reducing lung cancer mortality among study participants (Feld et al., 1995). [1]

Lung cancer occurs with much greater frequency among the elderly, which is typical of most cancers. The average age at diagnosis is approximately 68 years. Less than two percent of lung cancers are diagnosed before the age of 40 and five percent are diagnosed over the age of 85 (NCI, 1998). The distribution of the age at diagnosis of lung cancer is shown in Figure II.5-1. The steep incline in the probability of lung cancer diagnosis is clear in this diagram, with a peak around 68 years of age. Approximately 50 percent of all lung cancer cases are diagnosed in the relatively small age interval of 60 to 75 years. The data used to generate Figure II.5-1 are shown in Table II.5-1. The cumulative percents of lung cancer at various ages were calculated using the population-weighted distribution of occurrence.

[1]The above information is not currently used in a manner that alters the survival or costs associated with lung cancer.

Figure II.5-1

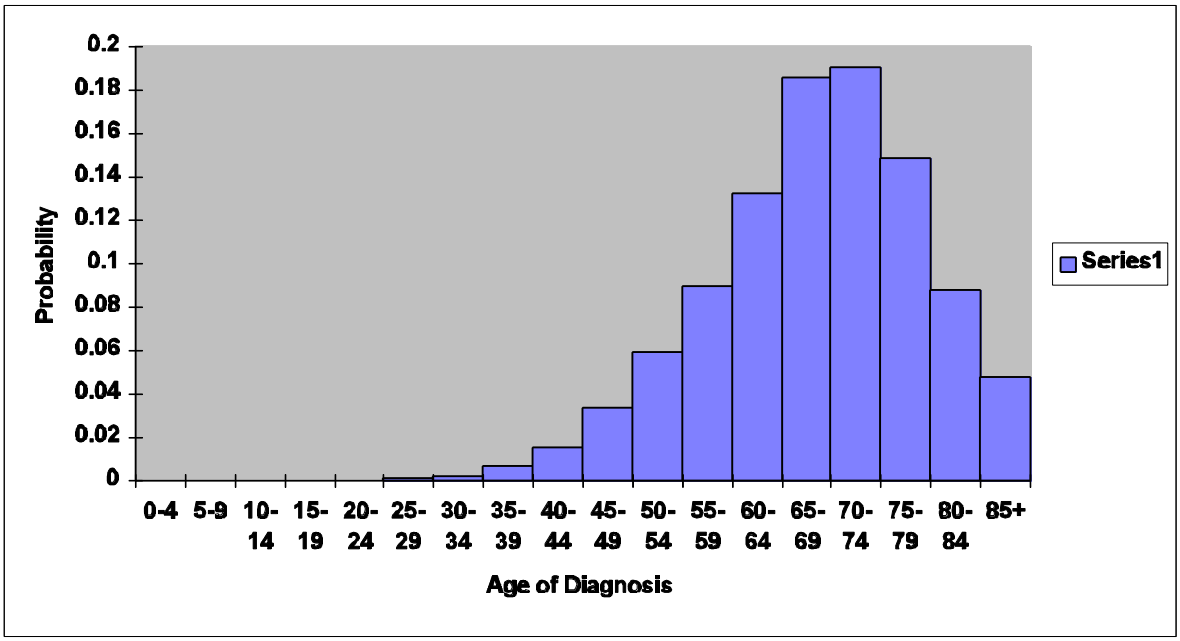

Table II.5-1. Age-specific Incidence of Lung Cancer			
Age Group	**Age-specific Rate of Diagnosis Per 100,000**	**Percent of All Lung Cancer Occurring in Age Group**	**Cumulative Percent of Lung Cancer**
0 - 14	0.0	0.0	0.0
15 - 34	2.8	0.30	0.34
35 - 39	5.2	0.7	1.0
40 - 44	13.0	1.5	2.5
45 - 49	34.5	3.3	5.8
50 - 54	77.7	5.9	11.8
55 - 59	141.0	8.9	20.7
60 - 64	226.7	13.2	33.9
65 - 69	321.5	18.6	52.5
70 - 74	375.2	19.0	71.5
75 - 79	391.1	14.9	86.4
80 - 84	349.3	8.8	95.2
85+	233.4	4.8	100.0
Based on NCI, 1998			

The age-specific incidence data were used in the Section B medical cost calculations. Data on incidence and age at diagnosis were obtained from NCI's Surveillance, Epidemiology, and End Results (SEER) reports and tables, obtained online in 1998 through the NCI Website at: http://www-seer.ims.nci.nih.gov.

II.5.A.2 Concurrent Effects

As with all cancers, lung cancer may spread to other organs. In addition, treatment of cancer, which usually includes chemotherapy, radiation, and surgery, has numerous adverse side effects and may, in itself, lead to death. For example, vinca alkaloids, used in lung chemotherapy, cause peripheral neuropathy in some patients. Radiation treatments of cancer have led to increased risks of other types of cancer, sterility, etc. Surgery, especially the removal of a lung, may cause long-term changes in health status, including reduced capacity or increased susceptibility to respiratory disease that may lead to death. These effects are associated with additional medical costs not considered in this chapter.

There is a strong link between lung cancer and smoking. Lung cancer patients are much more likely to have smoked than people who have not been diagnosed with lung cancer. Smoking is also associated with increased risks of many other diseases, including other cancers. There is no indication, however, that lung cancer *causes* these other diseases. The simultaneous or sequential occurrence of the diseases are likely due to their common causal link to smoking.

No data were located indicating that concurrent effects unrelated to lung cancer or its treatment were likely to occur as a result of this disease, although the same pollutants that cause lung cancer, especially respiratory irritants (e.g., silica, nickel), may cause other adverse effects. These effects can incur added medical costs not considered in this chapter. The risk assessment that serves as the basis for a benefits evaluation should include all adverse effects that are anticipated to result from exposure to the agent of interest.

II.5.A.3 Causality & Special Susceptibilities

As noted above, lung cancer is caused by exposure to tobacco smoke. It is also associated with certain air pollutants, such as radon and silica, and chemical pollutants. Table II-1 in Chapter II contains a list of chemicals known to cause or suspected of causing cancer (as reported in the EPA databases IRIS, HEAST, and HSDB). Most chemicals in the table were carcinogenic in animal studies. These studies do not provide organ-specific data because it is not generally assumed that cancer induction will necessarily occur at the same site in humans as in animals. Consequently, the chemicals listed in Table II-1 may cause lung cancer and/or other types of cancer. Evaluation of the likelihood of this occurrence would require additional research (risk assessment).

Link to Table II.1-1

NCI provides age-, sex-, and race-specific data regarding diagnosis of lung cancer from 1990 to 1994, which may be used to evaluate susceptibilities among population subgroups. The data must be used with care because diagnostic rates indicate occurrence only, and may, or may not indicate differences in susceptibility. See Chapter I.1 for a more detailed discussion of susceptibilities.

Link to Chapter I.1

NCI lung cancer diagnosis and mortality data show higher diagnosis and death rates among men than women. Lung cancer rates have been declining over the past 22 years among males under 65 years of age, however, while. lung cancer has been increasing in women. These dynamics have been attributed to a tapering off of smoking rates in males and a rapidly increasing rate of smoking among women in recent decades (NCI, 1998).

The rate of diagnosis among black males in 1994 was approximately 50 percent higher than among white males, which cannot be fully explained by smoking differences. The increased rate of lung cancer among black males may be due to exposure to pollutants in the workplace or ambient environment, exposure to carcinogens through other sources, or an inherently greater susceptibility to lung cancer among blacks (NCI, 1998). Some genetic factors have been identified that may increase the risk of lung cancer. Individuals who metabolize debrisoquine readily, as well as those lacking the MU phenotype of glutathione transferase, have an increased lung cancer risk. There is also evidence for Mendelian inheritance of lung cancer, indicating the importance of family history (Feld et al., 1995).

II.5.A.4 Treatments and Services

As noted above, lung cancer is usually treated with surgery, chemotherapy, and/or radiation, depending on the type of lung cancer, the stage of cancer at diagnosis, patient health, and other factors. The treatment of lung cancer can be defined more precisely by histologic type and specific location of the cancer in the lung. In this analysis, which is concerned with the average cost for all lung cancers, all histologic types and sub-sites are considered together.

Treatment is carried out in phases including initial diagnosis, initial treatment, follow-up and maintenance treatment, and, for those who do not survive, terminal treatment and palliative care. Some components of each treatment are unique to each phase, but most medical activities and services may occur more than once over the course of the disease from diagnosis to death or cure. For example, X-rays may be used in diagnosis, to provide ongoing status updates, to assist in determining initial and subsequent surgical and other treatment interventions, etc.

Initial diagnostic activities may include an evaluation of signs and symptoms, chest X-rays, computed tomography (CT) of the chest, magnetic resonance imaging (MRI) of the chest, sputum cytological analysis, percutaneous aspiration of pulmonary nodules, bronchoscopy, mediastinoscopy, thorascopy, thoracotomy, and other procedures. Staging of the disease occurs during this phase and is critical to determination of subsequent medical actions (Feld et al., 1995). Surgery is usually performed, and is associated with a relatively low mortality rate. Radiation and/or chemotherapy may be done with or without surgery. In many patients cancer has spread to the central nervous system, abdomen, bone marrow, and other areas, requiring additional treatment strategies (Feld et al., 1995).

Due to its poor prognosis, most patients receive terminal care. This care may include a variety of medical services, long-term care in a nursing facility, palliative care, family counseling, etc.

II.5.A.5 Prognosis

II.5.A.5.1 Background

As noted above, the overall prognosis for lung cancer patients is poor, with an average of 88 percent of patients dying of the disease within 10 years. Most deaths from lung cancer occur in the first four years, and approximately 60 percent of all patients die during the first year (NCI, 1998). Patients with early stages (I and II) of the disease have a 40 to 85 percent five-year survival rate (Bennet and Plum, 1996). Unfortunately, most diagnoses occur at later stages of the disease. Factors such as tumor size and location, histology, involvement of nodes, and the spread of cancer to other tissues affect outcome. Numerous new biochemical and immunological tests are used to provide additional information on the likely outcome (Feld et al., 1995).

II.5.A.5.2 Relative Survival Rates (RSRs)

The NCI SEER data reports were accessed online to obtain information regarding mortality and survival probabilities and the duration after diagnosis until death (NCI, 1998). Basic survival statistics on lung cancer are provided in this section because they relate to prognosis. Methods used to convert the NCI statistics to survival probabilities are discussed briefly in this section and in detail in Chapter II.2 on stomach cancer.

Link to Chapter II.2

NCI provides the RSR for each year post-diagnosis. The RSR is the number of observed survivors among these patients, divided by the number

of "expected" survivors among persons with the same age and gender in the general population (observed/expected). The equation for this is:

$$RSR = \frac{observed\ survival\ rate\ among\ cancer\ patients}{survival\ rate\ among\ age-\ and\ sex-matched\ cohort\ in\ the\ general\ population}$$

The RSR takes into account that there are competing causes of death that increase with age. The RSR for lung cancer patients during the first year post-diagnosis is 41 percent (NCI, 1998). A person with lung cancer would therefore have, on average, a one-year survival probability that is 41 percent of someone of the same age and gender in the general population. The RSRs provided by NCI for each year post-diagnosis are averages over all ages at diagnosis. An evaluation of the RSRs over the past 20 years indicates that they have increased by about 33 percent, with most of the progress occurring in the early 1970s (NCI, 1998). The most current information, the rates for 1988 through 1993, was used for the first through fifth years post-diagnosis Ten years of data were used to estimate survival for the sixth through tenth years post-diagnosis due to the need for a longer time span. Table II.5-2 lists the average RSRs for lung cancer for the first ten years post-diagnosis. The RSRs shown in Table II.5-2 were used to derive survival probabilities for lung cancer patients for each of the first ten years post-diagnosis.[2]

Table II.5-2. Average RSRs* for Lung Cancer for the First 10 Years Post Diagnosis

Years Post-Diagnosis (n)	Average RSR for n Years Post-Diagnosis
1	0.41
2	0.24
3	0.18
4	0.15
5	0.14
6	0.12
7	0.12
8	0.11
9	0.10
10	0.10

*The average RSR for each year post-diagnosis is the average of a set of RSRs reported by NCI (1998) as described in the text above.

[2] All vital statistic data in this document applicable to the general population were obtained from the National Center for Health Statistics (NCHS) Vital Statistics in the United States (NCHS, 1993).

Although most lung cancer patients will die of lung cancer, some may die of other causes. The probability of a lung cancer patient dying of causes other than lung cancer cannot be assumed to be the same as the probability of someone in the general population dying of other causes, particularly in the first few years post-diagnosis, when a lung cancer patient's probability of dying of lung cancer is quite high.[3]

The probability of a lung cancer patient dying of lung cancer and the probability of a lung cancer patient dying of some cause other than lung cancer in the *n*th year post-diagnosis, given survival to the *n*th year, were each derived from two known probabilities:

1) the probability of a lung cancer patient surviving through the *n*th year post-diagnosis, given survival to the *n*th year, and

2) the probability of a lung cancer patient dying of causes other than lung cancer in a matched cohort in the general population.

The derivation is explained in detail in the Appendix to Chapter II.2.

Link to Chapter II.2, Appendix II.2-A

Because each of the known probabilities depends on the number of years post-diagnosis and (minimally) on age at diagnosis, the derived probabilities were calculated for each of the ten years post-diagnosis and for the average age at diagnosis (68 years).[4] The following probabilities are shown in Table II.5-3:

1) survival through the *n*th year,
2) dying of lung cancer during the *n*th year, and
3) dying of some other cause during the *n*th year.

Probabilities of survival and dying of all causes among all members of the general population aged 68 were obtained from the National Center for Health Statistics (NCHS) Vital Statistics in the United States (NCHS,

[3] This difference becomes clear in the extreme case in which the probability of dying of an illness is extremely high. Suppose, for example, that the probability of dying of all causes except for illness X is 0.025 in the general population. Suppose that in a cohort of patients diagnosed with illness X, the probability of dying from illness X in the first year post-diagnosis is 0.99. If the probability of dying of other causes in this cohort equaled that in the general population (0.025), then the probability of someone in the cohort dying would be greater than 1.0.

[4] Ten years is a generous follow-up period during which most individuals who will die of lung cancer have done so. It is also used as a reasonable maximum duration of maintenance care and treatment for those who do not die of lung cancer.

1993). These probabilities are also shown in Table II.5-3. The values in this table are used in Section II.5.B to calculate the expected medical costs of lung cancer patients.

Table II.5-3. Probabilities of Survival and Mortality for Lung Cancer Patient Diagnosed at Age 68[a]

Years post-diagnosis (n)	A Cohort in the General Population (Matched)		A Cohort of Lung Cancer Patients			
	Probability of surviving n years	Probability of dying in *n*th year of causes other than lung cancer, given survival to the *n*th year[b]	Relative Survival Rate[c]	Probability of surviving through the *n*th year post-diagnosis[d]	Probability of dying of lung cancer in the *n*th year post-diagnosis[e]	Probability of dying of other causes in the *n*th year post-diagnosis[f]
0	1.000	---	---	1.0	---	---
1	.977	.023	.41	.401	.586	.014
2	.953	.025	.24	.229	.165	.007
3	.928	.027	.18	.167	.057	.005
4	.901	.029	.15	.135	.028	.004
5	.872	.031	.14	.122	.009	.004
6	.843	.034	.12	.101	.018	.003
7	.812	.037	.12	.097	.000	.003
8	.779	.040	.11	.086	.008	.003
9	.745	.044	.10	.075	.008	.003
10	.710	.047	.10	.071	.000	.003

a. The survival and mortality probabilities for lung cancer patients presented here are derived from the RSRs obtained from NCI and the survival probabilities for a matched cohort in the general population. They are therefore only *estimates* of the underlying population survival and mortality probabilities for lung cancer patients. Whereas the underlying population probabilities are likely to follow a smooth trend (over years post-diagnosis), the estimates exhibit some of the "bumpiness" around that trend that typically results from normal sampling variability. This variability will also be true of any other probabilities (such as the conditional probabilities discussed below) that are derived from the estimated probabilities shown here.
b. The probabilities in the general population of dying from lung cancer are 0.000256 in the 70-74 year age group, and 0.000348 in the 75-79 year age group. The probabilities in column (3) were derived by subtracting these probabilities from the corresponding probabilities of dying from any cause in the *n*th year, given survival to the *n*th year.
c. From Table II.5-2.
d. See Chapter II.2 for an explanation of the derivation of these probabilities.

II.5.B Costs of Treatment and Services

II.5.B.1 Methodology

II.5.B.1.1 Overview

There is no single typical case or treatment pattern for lung cancer because of individual differences in the stage of cancer at diagnosis, multiple treatment options, patient health and age, and other factors; however, average costs can be calculated. Treatment of lung cancer may occur over a brief or extended period of time, and costs may be limited or substantial. Lung cancer has a relatively high mortality rate of 88 percent, as discussed in Section A. The medical costs of those who die of the disease are usually very different than for those who survive (this is discussed in more detail in Chapter I.1). This chapter therefore provides costs for the "average" lung cancer patient, as well as for survivors and nonsurvivors as separate patient groups.

Link to Chapter I.1

II.5.B.1.2 Medical Cost Data

II.5.B.1.2.1 Sources

Medical cost data would ideally be obtained on current medical expenditures. Although data files are maintained by public and private sector sources, they are not readily available. In addition, to obtain reliable cost estimates it is necessary to evaluate very large databases of charges from a variety of sources. This activity was not practical for the development of this chapter. A data search was conducted to locate information in the medical economics literature regarding medical costs associated with lung cancer. In addition to a literature search, most federal agencies dealing with cancer, disabilities, medical costs and their management, and related issues were contacted for information and the various federal databases were discussed with senior staff at these agencies.

Very recent cost data were not located.[5] Current (1994) cancer data were obtained regarding incidence and survival (as reported in Section II.5.A, above), and were used with cost data from the 1980s described below. The cost estimates presented in this section are based primarily on the work of Baker et al. (1989) and Hartunian et al. (1981) and on two sources of statistical data: the National Cancer Institute (1998) and Vital Statistics of the United States, 1993 (NCHS, 1997). These data were evaluated and cost elements were used to calculate lifetime estimates of the direct medical costs due to lung cancer.

[5] Studies were located that used more recent cost data than the data used in this analysis. Serious limitations existed, however (data were incomplete), and so the studies were not used. They are reported in the "Other Studies" section at the end of Section B.

Based on the 1997 review of the medical literature carried out for the development of this chapter, there do not appear to be widely-adopted new treatment methods for lung cancer that substantially alter either the medical costs or the survival rates for most patients. Consequently, the cost estimates presented in this chapter may be considered appropriate under most circumstances (e.g., regional costs may vary).

II.5.B.1.2.2 Baker et al.'s Cost Estimation Method

Baker et al. (1989) used the Continuous Medicare History Sample File (CMHSF) to estimate the per-patient average lifetime medical cost of treating lung cancer based on data files from 1974 to 1981. They chose CMHSF because:

1) it is a nationally representative sample of the Medicare population (five percent), covering over 1.6 million patients;
2) it is longitudinal, dating from 1974 to 1981; and
3) it captures the majority of medical expenses for each beneficiary.

Five Medicare files are included in the CMHSF, which cover:

1) inpatient hospital stays,
2) skilled nursing facility stays,
3) home health agency charges,
4) physicians' services, and
5) outpatient and other medical services.[6]

Costs that were not included are outpatient prescription medications and nursing home care below the skilled level.

Because CMHSF provides no indication of initial diagnosis, Baker et al. assumed that disease onset occurred when a diagnosis of lung cancer was listed on a hospitalization record following a minimum of one year without a lung cancer diagnosis. This assumption is reasonable due to the high frequency of hospitalization associated with the disease (i.e., individuals diagnosed with lung cancer would be hospitalized). Only patients with an initial diagnosis during the years covered by the database (1974-1981) were included.

[6] See Baker et al. (1989 and 1991) for further details. Baker et al. (1991) contains additional descriptive data regarding the database and methods used for the cost analysis; however, it does not contain cost data for lung cancer.

Costs associated with lung cancer were assigned to three post-diagnostic time periods:

- initial treatment, during the first three months following diagnosis;
- maintenance care, between initial and terminal treatment; and
- terminal treatment during the final six months prior to death.

As noted in Chapter I.1, the amount paid for service may differ from the actual medical costs because many insurers and federal programs either 1) pay only a portion of total costs or 2) pay more than actual costs to underwrite the care providers' losses due to underpayment from other sources.

Link to Chapter I.1

Baker et al. used provider charges, rather than Medicare reimbursements (which represent only a portion of most total charges), thus providing a more accurate cost estimate. To improve the accuracy of the cost estimates, Baker et al. included cost data on coinsurance, deductibles, and other cost components. They made four adjustments to the cost estimates calculated from the CMHSF. First, charges were added for skilled nursing facilities (SNFs) not covered by Medicare by multiplying the "length of stay" at an SNF (computed from admission and discharge dates) by the average daily SNF charge. Second, the annual Medicare Part B deductible of $60 was added to the reimbursed charges in the database. Third, since Medicare pays only 80 percent of physicians' charges, Baker et al. scaled these reimbursements to 100 percent of physicians' charges to better reflect social costs. Finally, they inflated all dollar values to 1984 dollars using the Medical Care component of the Consumer Price Index.

II.5.B.1.2.3 Cost Estimates by Treatment Period

Medical costs associated with the initial, maintenance, and terminal cancer care treatment periods were itemized in Baker et al. (1989) and are shown in Table II.5-4. The 1989 paper did not report incremental costs or the costs of other medical services that would be anticipated to occur while the patient was receiving cancer treatment (i.e., co-morbidity/background costs). In order to estimate the incremental costs, a co-morbidity cost of $2,988 per year (1984 dollars) from Baker et al. (1991) was used in this analysis. (This is equivalent to $6,394 in 1996 dollars using the CPI multiplier of 2.14 for 1984 to 1996.) The co-morbidity cost was pro-rated for this analysis using the specified durations for the initial (three-month) and terminal (six-month) treatment periods.

Table II.5-4 lists the incremental costs calculated for the three treatment periods. Total costs are reported for the initial and terminal care periods. Annual costs for the maintenance period are shown and are further discussed in the "Lifetime Costs" section below. Using the Medical Care

component of the Consumer Price Index (CPI-U), all costs are inflated to 1996 dollars for purposes of this handbook. (The adjustment factor for 1984 to 1996 is 2.14; Bureau of Labor Statistics.)

Table II.5-4. Average Per Patient Costs for the Three Periods of Treatment for Lung Cancer in 1996 dollars
Costs adjusted for inflation using the Medical Care component of the Consumer Price Index (CPI-U) 1996:1984 = 2.14 (Bureau of Labor)

Treatment Period	Incremental Cancer Treatment Cost
Initial (3 months)	$26,042
Maintenance (per year)	$11,325
Terminal (6 months)	$30,112

(Based on Baker et al., 1989, with comorbidity charges from Baker et al., 1991.

II.5.B.1.3 Calculation of Lifetime Cost Estimates for the "Average" Lung Cancer Patient

This section contains a discussion of the calculation of lifetime medical costs for the "average" lung cancer patient. Sections that follow discuss methods and results of calculations for estimating costs for survivors and nonsurvivors of lung cancer separately. These separate approaches were used to address specific requirements of different activities that EPA carries out using direct medical cost data. Although Baker et al. (1989) provide useful cost estimates for the three treatment periods, they do not provide information on two critical aspects of medical costs:

1) costs for survivors versus nonsurvivors of lung cancer. These values may differ substantially. For example, survivors would not have terminal care costs and may receive maintenance services for an extended time period; and

2) estimates of the duration of the maintenance periods.

Data regarding age at diagnosis of lung cancer were obtained from NCI (1998). Survival and mortality probabilities for each year post-diagnosis were derived from relative survival rates obtained from NCI (1998), as discussed in Section II.5.A.5.2.

Link to Section II.5.A.5.2

This information was used to address many time-related medical cost issues. For some aspects of the analysis, however, detailed information

was not available and average values have been used as a reasonable approximation (e.g., a ten-year maintenance period was assumed for survivors of lung cancer). When average values or other assumptions are used in this analysis, they are so noted.

As previously noted, there are not substantial differences in survival related to age at diagnosis, and NCI does not provide age-specific RSRs for each year post-diagnosis. Consequently, it was assumed for this analysis that the relative survival rates for lung cancer were the same for all ages. The survival and mortality probabilities for lung cancer patients, which are incorporated into calculations of expected medical costs as discussed below, are based on this assumption.

The analysis assumes that death always occurs midyear. All lung cancer patients are therefore assumed to incur the costs of initial treatment during the first three months of the illness. The costs incurred after that during the first year depend on whether the patient:

(1) survives through the year,
(2) dies of lung cancer during the year, or
(3) dies of some other cause during the year.

Patients who survive through the year incur the costs of initial treatment ($26,042) during the first three months, and then incur nine months' worth of maintenance care costs ($0.75 \times \$11,325 = \$8,494$) during the remainder of the year. The total cost incurred during the first year by those patients who survive the year is therefore $\$26,042 + \$8,493 = \$34,535$.

Lung cancer patients who die of lung cancer during the first year incur the initial treatment cost and then incur terminal care costs for the remaining three months of their lives (because those who die are assumed to die midyear). Total costs during the first year post-diagnosis in this case are therefore $\$26,042 + (0.5 \times \$30,112) = \$41,098$.

Finally, the small percentage of lung cancer patients who die of causes other than lung cancer during the first year post-diagnosis incur the initial treatment costs and then incur three months' worth of maintenance care costs. Total first-year costs for these patients are therefore $\$26,042 + 0.25 \times \$11,325 = \$34,536$.

The expected medical costs for lung cancer patients during the first year post-diagnosis, then, may be expressed as:

Expected First-Year Cost: initial treatment costs + [maintenance care costs for nine months × probability of survival through first year + terminal care costs for three months × probability of dying of lung cancer during first year + maintenance care costs for three months × probability of dying of other causes during the first year]

Example: Expected first-year medical costs of a lung cancer patient diagnosed at age 68

As noted above, all lung cancer patients incur an initial treatment cost of $26,042. Those who survive through the year also incur maintenance care costs for the remaining three quarters of the year. The total first-year costs of those who survive the year are:

Initial treatment:	$26,042
Maintenance treatment:	$8,493 (.75 × $11,325)
Total First-Year Cost	$34,535

More than half of lung cancer patients die of lung cancer during the first year. Those who do will incur the initial treatment costs plus half of the terminal care costs. The total first-year costs of those who die of lung cancer during the year are:

Initial treatment:	$ 26,042
Terminal care:	$15,056 (.50 × $30,112)
Total First-Year Cost	$41,098

Finally, a small percentage of patients will die of competing illnesses during the first year. Because those who die of causes other than lung cancer are assumed to die at the midpoint of the year, costs during the first half of the year are assumed to consist of the initial treatment costs for three months, plus three months of maintenance care costs as follows:

Initial treatment:	$26,042
Maintenance treatment:	$2,831 (.25 × $11,325)
Total First-Year Cost	$28,873

For each subsequent year, costs consist entirely of maintenance care costs for those who survive the year. For those who do not survive the year, costs depend on whether death was due to lung cancer or other causes. For those who die of lung cancer during the *n*th year, costs incurred that year consist of six months of terminal care costs, or $30,112. For those

who die of other causes during the *n*th year, there are six months of maintenance care costs, or 0.5 × $11,325 = $5663.

The expected first-year medical cost incurred by the "average" lung cancer patient diagnosed at age 68 is a weighted average of the costs of those who survive the first year, those who die of lung cancer during the first year, and those who die of other causes during the first year, where the weights are the probabilities of each of these occurrences. The weighted average medical cost were calculated for ten years post diagnosis, and expected costs were summed over the ten years. This was assumed to be a reasonable period over which additional medical costs associated with lung cancer (i.e., maintenance care costs) would be incurred by lung cancer patients. In reality, there may be follow-up care and continued testing over a longer period; however, no data were available regarding those costs. They would certainly be less than $11,325 per year.

The expected medical costs for lung cancer patients during the *n*th year post-diagnosis, for *n*>1, then, may be expressed as:

> **<u>Expected *n*th Year (*n*>1) Cost:</u> [maintenance care cost for one year × probability of survival through *n*th year + terminal care cost for six months × probability of dying of lung cancer during the *n*th year + maintenance care cost for six months× probability of dying of other causes during the *n*th year]**
>
> **<u>Expected Lifetime Cost</u> = Expected first-year cost + the sum of the (discounted) expected subsequent-year costs**

The first year of treatment is calculated differently from other years because the first three months of that year are spent in "initial" treatment, and the costs for that period of intensive medical care and surgery are calculated separately.

The mathematical equation for the expected lifetime medical costs incurred by the "average" lung cancer patient over a ten-year period is:

$$\$26{,}042 + (\$11{,}325 \times 0.75 \times ps_1) + (\$11{,}325 \times 0.25 \times pm_1{}^{o}) + (\$30{,}112 \times 0.5 \times pm_1{}^{sc})$$

$$+\sum_{y=2}^{10} \left[(ps_y \times \frac{\$11{,}325}{(1+r)^{y-1}}) + (pm_y{}^{o} \times \frac{\$5{,}663}{(1+r)^{y-1}}) + (pm_y{}^{sc} \times \frac{\$30{,}112}{(1+r)^{(y-1)}}) \right]$$

Where:

y	=	the year post-diagnosis,
ps	=	the probability of surviving through the year,
pm^{sc}	=	the probability of dying of lung cancer during the year

pm^o = the probability of dying from other causes during the year,

r = the discount rate

The cost estimates for each year post-diagnosis and the estimate of undiscounted expected total cost for a ten year period are shown in Table II.5-5 for the "average" lung cancer patients diagnosed at age 68. The survival and mortality probabilities necessary for the calculations of costs are shown in Table II.5-3.

Link to Table II.5-3

II.5.B.1.4 Calculation of Lifetime Cost Estimates Separately for Lung Cancer Survivors and Nonsurvivors

II.5.B.1.4.1 Survivors and Nonsurvivors

As noted above, there are differences in medical services provided to lung cancer patients who survive the disease (survivors) versus those who die of the disease (nonsurvivors). Based on cost estimates by Baker et al. (1989), terminal care is provided for approximately six months to terminally ill cancer patients. The costs to nonsurvivors for this care ($30,112) is considerably higher than costs for survivors who receive maintenance care for the same period of time ($5,662).[7]

EPA may use the value of a statistical life (VSL) for nonsurvivors, and thus separate costs for survivors and nonsurvivors were calculated. The method shown above to calculate costs for the "average" patient uses the unconditional probabilities of survival and mortality listed in Table II.5-3. The method used to calculate costs for survivors and nonsurvivors separately requires the probabilities that are conditional on being either a survivor or nonsurvivor of lung cancer.

[7] Nonsurvivors include only those who die of lung cancer and do NOT include those who die of any other causes.

Table II.5-5. Expected Costs of Medical Services (in 1996$) for Lung Cancer Patients (Age of Onset = 68)

	Medical Costs in the *n*th Year (undiscounted)			
Years Post-Diagnosis (n)	**if survive through the *n*th year**	**if die of lung cancer in the *n*th year**	**if die of other causes in the *n*th year**	**Expected Medical Costs for the *n*th Year Post-Diagnosis (Discounted)**
1[b]	34,535	41,098	28,873	38,300
2	11,325	30,112	5.662	7,601
3	11,325	30,112	5,662	3,636
4	11,325	30,112	5,662	2,393
5	11,325	30,112	5,662	1,684
6	11,325	30,112	5,662	1,694
7	11,325	30,112	5,662	1,133
8	11,325	30,112	5,662	1,239
9	11,325	30,112	5,662	1,101
10	11,325	30,112	5.662	831
Expected Total Cost Through the 10th Year Post-Diagnosis for a Lung Cancer Patient Diagnosed at Age 68				59,612

a. The probabilities listed in this table are from Table II.5-3. The costs are listed in Table II.5-4.
b. First-year costs include the charge for "initial" therapy ($26,042). The duration of maintenance care is adjusted accordingly (see text for discussion).
c. Calculated using the probabilities in Table II.5-3 and the costs in Columns (5), (6), and (7) of this table.

The conditional probability of a lung cancer nonsurvivor dying in the *n*th year is the number of nonsurviving lung cancer patients who die of lung cancer during the *n*th year divided by the total number of lung cancer nonsurvivors. Likewise, the conditional probability of a lung cancer survivor dying in the *n*th year is the number of surviving lung cancer patients who die of lung cancer during the *n*th year divided by the total number of lung cancer survivors. A detailed explanation of the derivation of these values is provided in Chapter II.2. The conditional probabilities of survival and mortality for survivors and nonsurvivors of lung cancer are given in Table II.5-6.

Link to Chapter II.2

Table II.5-6. Conditional Probabilities of Survival and Mortality for Survivors and Nonsurvivors of Lung Cancer (Age of Onset = 68) a

Years Post-Diagnosis (n)	Lung Cancer Survivors		Lung Cancer Nonsurvivors	
	Conditional probability of:		Conditional probability of:	
	Surviving through the *n*th year	Dying of some other cause during the *n*th year	Surviving through the *n*th year	Dying of lung cancer during the *n*th year
1	.886	.114	.334	.666
2	.829	.056	.146	.188
3	.791	.039	.081	.065
4	.758	.033	.050	.032
5	.727	.030	.039	.011
6	.699	.029	.019	.020
7	.671	.028	.019	.000
8	.643	.028	.009	.009
9	.616	.027	.00	.009
10	.589	.027	.00	.000

a. As noted for Table II.5-3, the survival and mortality probabilities for lung cancer patients presented here are derived from the relative survival rates obtained from NCI and the survival probabilities for a matched cohort in the general population. They are therefore only *estimates* of the underlying population survival and mortality probabilities for lung cancer patients. Whereas the underlying population probabilities are likely to follow a smooth trend (over years post-diagnosis), the estimates exhibit some of the "bumpiness" around that trend that typically results from normal sampling variability. This variability will also be true of any other probabilities (such as the conditional probabilities discussed below) that are derived from the estimated probabilities shown here.

II.5.B.1.4.2 Calculation of Lifetime Cost Estimates for Lung Cancer Survivors

As shown in the example portion of Section II.5.B.1.3, cost estimates are calculated by summing the costs of the different treatment phases over the lifetime of the lung cancer patient. The expected medical costs for lung cancer survivors during the first year post-diagnosis may therefore be expressed as:

<u>Expected First-Year Cost:</u> initial treatment costs + [maintenance care costs for nine months × probability of survival through first year + maintenance care costs for three months × probability of dying of other causes during the first year]

The expected medical costs for lung cancer survivors during the *n*th year post-diagnosis, for *n*>1, then, may be expressed as:

> **<u>Expected *n*th Year (*n*>1) Cost:</u> [maintenance care cost for 1 year × probability of survival through *n*th year + maintenance care cost for six months × probability of dying of other causes during the *n*th year]**
>
> **<u>Expected Lifetime Cost</u> = Expected first-year cost + the sum of the (discounted) expected subsequent-year costs**

Note that the probabilities used in these calculations are the conditional probabilities given in Table II.5-6. They are conditional on the lung cancer patient not dying of lung cancer.

Using the initial, maintenance, and terminal care costs from Table II.5-6, the mathematical equation for the lifetime costs incurred by lung cancer survivors is:

$$\$26{,}042 + pm_1^s \times 0.25\ (\$11{,}325) + ps_1^s \times .75 \times \$11{,}325 + \sum_{y=2}^{10} \left[ps_y^s \frac{\$11{,}325}{(1+r)^{y-1}} + pm_y^s \frac{\$5{,}662}{(1+r)^{y-1}} \right]$$

where: y = the year post-diagnosis
ps^s = the conditional probability of survival for that year, conditional on being a survivor of lung cancer
pm^s = the conditional probability of mortality for that year, conditional on being a survivor of lung cancer
r = the discount rate.

The expected medical costs for lung cancer survivors for each year post-diagnosis, as well as the expected total medical costs over ten years post-diagnosis, are shown in Table II.5-7.

Table II.5-7. Expected Undiscounted Costs of Medical Services (in 1996$) for Survivors of Lung Cancer (Age of Onset = 68)

Years Post-Diagnosis (n)	Medical Costs Through the 10th Year Post-diagnosis[a] (undiscounted)		
	Medical Cost if Survive Through the *n*th Year	Medical Cost if Die of other Causes in the *n*th Year	Total Cost Based on Weighted Average[c]
1[d]	34,535	28,873	33,889
2	11,325	5,662	9,713
3	11,325	5,662	9,173
4	11,325	5,662	8,768
5	11,325	5,662	8,411
6	11,325	5,662	8,077
7	11,325	5,662	7,756
8	11,325	5,662	7,438
9	11,325	5,662	7,124
10	11,325	5,662	6,818
Expected Total (Undiscounted) Cost Through the 10th Year Post-Diagnosis:			**107,167**

a. Costs are based on data reported in Table II.5-4, adapted from Baker et al., 1989.
b. Probabilities of survival and mortality, taken from Table II.5-6, are conditional on surviving lung cancer.
c. Weighted average of the costs incurred by survivors who survive the year and the costs incurred by survivors who die of other causes during the year. Weighting is based on the conditional probabilities provided in Table II.5-6.
d. Costs during the first year include a charge for "initial" therapy ($26,042), and the duration of maintenance or terminal care is adjusted accordingly. See text for discussion.

II.5.B.1.4.3 Calculation of Lifetime Cost Estimates for Lung Cancer Nonsurvivors

Nonsurvivors of lung cancer will incur initial, maintenance, and terminal costs. Their lifetime medical costs associated with the disease can be calculated from the costs per treatment period shown in Table II.5-4 and the conditional probabilities for nonsurvivors of lung cancer shown in Table II.5-6.

As Table II.5-6 indicates, most lung cancer patients who will ultimately die of lung cancer do so in the first few years post-diagnosis. About 85 percent die in the first two years. Deaths from lung cancer after the first four years are minimal. As with lung cancer survivors, medical costs for nonsurvivors each year post-diagnosis were calculated as a weighted average of the costs incurred by those who survive the year and those who die (of lung cancer) during the year.

It was assumed that those who die during a year receive six months of care (as was done for the survivors above). It was also assumed that terminal care lasting six months would be provided to all nonsurvivors. Therefore, unless death occurred during the first year, when initial care was assumed to occur, the care costs which were assigned to the last year of life were terminal costs. If death occurred during the first year post-diagnosis, it was assumed that initial care and three months (one-half of the total) of terminal care were provided.

The general description of medical costs for nonsurvivors may be expressed as:

> **Expected First-Year Cost: [initial costs + one-half terminal costs] × probability of mortality during the first year + [initial costs + maintenance care costs for nine months] × probability of survival for first year**
>
> **Expected *n*th Year (*n*>1) Cost: maintenance care cost for 1 year × probability of survival through *n*th year + terminal costs × probability of mortality in *n*th year**
>
> **Expected Lifetime Cost = Expected first-year cost + the sum of the (discounted) expected subsequent year costs**

As with the cost calculations for lung cancer survivors, the probabilities used in these cost calculations are the conditional probabilities given in Table II.5-6: in this case, conditional on dying of lung cancer.

Using the initial, maintenance, and terminal care costs from Table II.5-6, the mathematical equation for the expected lifetime costs incurred by nonsurvivors is:

$$\$26{,}042 + pm_1^{ns} \times 0.5\ (\$30{,}112) + ps_1^{ns} \times .75 \times \$11{,}325 + \sum_{y=2}^{10} \left[ps_y^{ns} \frac{\$11{,}325}{(1+r)^{y-1}} + pm_y^{ns} \frac{\$30{,}112}{(1+r)^{y-1}} \right]$$

where: y = the year post-diagnosis
ps^{ns} = the conditional probability of survival for that year, conditional on being a nonsurvivor of lung cancer
pm^{ns} = the conditional probability of mortality for that year, conditional on being a nonsurvivor of lung cancer
r = the discount rate.

The costs are summed over all years from diagnosis to death. Maintenance care costs are not added in the last year of life because during the six months that are assumed to constitute this period the patient is assumed to receive terminal care. (The discounted results are shown in the "Results" section that follows.) The approach is the same as that shown in the example in Section II.5.B.1.3 When the costs for each year are summed over a period of ten years post-diagnosis, during which essentially all patients who will die of lung cancer have done so, the total cost per nonsurvivor is obtained. These costs are shown in Table II.5-8.

Link to Section II.5.B.1.3

The results shown above can be used to calculated costs for an "average" lung cancer patient, from the costs calculated for survivors and nonsurvivors. The expected medical costs of a lung cancer patient can be calculated as a weighted average of the expected costs of survivors and nonsurvivors of lung cancer. This approach, which was not used to calculated costs for the "average" patient in this chapter, yields the same results as the approach shown in Section II.5.B.1.3. A discussion of why these to approaches yield the same results is provided in Chapter II.2 (Section II.2.B.2.3). In brief, the approach used in this chapter for the average patient uses cost data for all patients, weighted by their average utilization of services. If the survivor and nonsurvivor data were used, which incorporates utilization of services, cost results obtained through separate calculations for the two subgroups are simply re-aggregated based on each group's proportional contribution to the cost.

Link to Chapter II.2.B.2.3

Table II.5-8. Expected Undiscounted Costs of Medical Services (in 1996$) for Nonsurvivors of Lung Cancer (Age of Onset = 68)			
Years Post-Diagnosis (n)	Medical Costs Through the 10th Year Post-diagnosis[a] (undiscounted)		
	Medical Cost if Survive Through the *n*th Year	Medical Cost if Die in the *n*th Year	Total Cost Based on Weighted Average[c]
1[d]	34,535	41,098	38,905
2	11,325	30,112	7,311
3	11,325	30,112	2,877
4	11,325	30,112	1,519
5	11,325	30,112	761
6	11,325	30,112	818
7	11,325	30,112	224
8	11,325	30,112	389
9	11,325	30,112	274
10	11,325	30,112	9
Expected Total (Undiscounted) Cost Through the 10th Year Post-Diagnosis:			53,088

a. Costs are based on data reported in Table II.5-5, adapted from Baker et al., 1989.
b. Probabilities of survival and mortality, taken from Table II.5-6, are conditional on dying of lung cancer within 10 years post-diagnosis.
c. Weighted average of costs incurred by nonsurvivors who survive the year and those who die during the year. Weighting is based on the conditional probabilities shown in Table II.5-6.
d. Costs during the first year include "Initial" therapy ($26,042) , and pro-rated maintenance or terminal care. See text for discussion.

II.5.B.2 Results of Medical Cost Analysis

The per patient lifetime direct medical costs calculated for the "average" lung cancer patient (as shown in Table II.5-5), lung cancer survivors (as shown in Table II.5-7) and lung cancer nonsurvivors (as shown in Table II.5-8) diagnosed at age 68 are listed in Table II.5-9. Undiscounted costs and costs discounted at three, five, and seven percent back to year one (time of diagnosis) are shown. Discounting was carried out for ten years following diagnosis (which, for nonsurvivors, comprises the full duration of treatment time because virtually all patients that are going to die of lung cancer do so within ten years) and comprises the assumed full duration of maintenance care for survivors.

Table II.5-9. Incremental Per-capita Medical Costs for the Average Lung Cancer Patient, Survivors, and Nonsurvivors (Diagnosed at Age 68) Undiscounted and Discounted at 3, 5, and 7 Percent ($1996)

Patient Group	Discount Rate			
	Undiscounted	3%	5%	7%
Survivors	$107,167	$97,822	$92,572	$87,966
Nonsurvivors	$53,088	$52,215	$51,692	$51,211
Average Patient	$59,612	$57,716	$56,624	$55,645

See text for a definitions of patient groups.

The results show much higher costs for survivors than nonsurvivors, due primarily to their ongoing maintenance care. It is noted that although a ten-year maintenance period for lung cancer survivors is assumed (with adjustment for background mortality that reduces utilization), the actual average period of maintenance is not known and is likely to vary considerably among individuals, depending on age, health status, access to care, and other factors. Most lung cancer patients (88 percent) die of the disease, and their costs are the major cost element in determining the "average" patient costs. The uncertainty surrounding the period of maintenance care for survivors therefore does not have a substantial impact on the cost estimates for the "average" patient.

II.5.B.3 Other Studies

The results of these studies are examined: Mor et al. (Draft 1990), Hartunian et al. (1981), Oster et al. (1984), Riley et al., (1995). The Baker et al. study has a combination of characteristics of study design and data quality that makes it preferable to the other studies, as discussed below.

II.5.B.3.1 Mor et al.

The Mor et al. (1990) study tracked prospectively eligible Medicare beneficiaries in Rhode Island from 1984-1986 by "examining pathology reports in nine Rhode Island hospitals." The medical records were linked to Medicare inpatient and outpatient claims data. Medicare claims files were reviewed, and the charges associated with lung cancer were aggregated for the first year post-diagnosis. The study has three limitations that make it less appropriate for use than the Baker et al. study:

1) the study was limited to Medicare beneficiaries in Rhode Island;
2) the study has not yet been submitted to a refereed journal;
3) the study covers only one year of treatment;
4) costs are only those reimbursed by Medicare, rather than all costs.

The study does, however, use more recent data than those used by Baker et al. Mor et al.'s estimates for the cost of lung cancer in the first year after diagnosis (i.e., lifetime cost, since the majority of lung cancer patients survive less than one year) is $40,051 (inflated from 1986 to 1996 dollars using the CPI-U for Medical Care). This value agrees closely with the results of Baker et al.'s work.

II.5.B.3.2 Hartunian et al.

Hartunian et al.'s (1981) method of estimating the costs of illness has been discussed in Chapter I.1. The authors defined expected treatment on a yearly basis, developed annual costs of the treatment, and combined the cost data with survival data. Using this method, they estimated the costs of cancer at eight sites, including cancer of the respiratory system.

Link to Chapter I.1

Hartunian et al. estimated the costs of inpatient stays for respiratory cancer using a 1976 study by Scotto and Chazze, in which 6,332 newly diagnosed cancer patients were followed over a two-year period to establish hospitalization and payment patterns. For other costs, the authors relied on a questionnaire, called the Patient Interview Book (PIB), delivered as part of the Third National Cancer Survey. Using the PIB, about 8,500 cancer patients or surviving relatives were interviewed regarding the costs of non-hospital medical services. The PIB presents the proportional distribution of total medical expenditures between hospital and non-hospital charges. Applying these proportions to the hospital costs from Scotto and Chiazze, Hartunian et al. estimated non-hospital costs. Hartunian et al. presented their estimates of the present value of total direct costs of respiratory cancers in 1975 dollars, discounted by six percent, by the age of onset for males and females. Inflated to 1996 dollars using the CPI-U for Medical Care (Bureau of Labor Statistics), their cost estimates, which approximate Baker et al.'s estimates are:

Males	
Age 65-74	$37,201
Age 75+	$34,821

Females	
Age 65-74	$36,838
Age 75+	$34,508

The Hartunian data are quite old (over 20 years) and both survival and treatment methods have changed since that time.

II.5.B.3.3 Oster et al.

Oster et al. (1984) estimated the cost of lung cancer as part of an analysis of the cost of smoking. Their methodology followed that laid out by Hartunian et al. Annual cost estimates were multiplied by survival rates and discount factors and summed to arrive at a present value of the direct costs of treating lung cancer. Oster et al.'s cost estimates were presented in 1980 dollars for all ages. Using the CPI-U for Medical Care (Bureau of Labor Statistics), these prices are inflated to 1996 dollars. The resulting cost estimates (using a discount rate of three percent) are:

Males $57,861

Females $60,047

Although these estimates are substantially higher than the Baker et al., estimate, Oster et al.'s estimate of the cost of a lung cancer patient who survives between zero and one year past disease onset is $45,013 in 1996 dollars. This cost estimate is similar to that developed based on Baker et al. A potential explanation for the remaining difference in the cost estimates is that Oster et al. assume that all patients incur the same costs in their first year of disease regardless of their survival period. This cost scheme may be realistic, but it is also possible that patients with relatively long survival periods were diagnosed with less advanced cancer cases. These cancer cases may require less extensive treatment and may therefore be associated with lower first-year costs.

II.5.B.3.4 Riley et al

A study of medicare payments from diagnosis to death in elderly cancer patients was carried out by Riley et al. (1995). The cost estimates are based on Medicare payments only, which do not include: most nursing home care, home health care, pharmaceuticals unless supplied for inpatients, out-of-pocket expenses, deductibles, charges in excess of Medicare paid by other sources (e.g., coinsurance), and other related medical services that are not covered by Medicare.

Medicare patients younger than 65 were not included, and the average age at diagnosis of the lung cancer cohort was 73.6 years, in contrast with the 68-year national average. Riley et al. note that patients diagnosed at younger ages have higher costs. In addition, those diagnosed at earlier stages have a better prognosis, but may have higher medical costs (due to longer continuing care).

Medical costs are reported for all patients who were diagnosed with lung cancer, regardless of other diseases or their ultimate causes of death. Due to the link between lung cancer, smoking, and numerous other diseases, this method is especially problematic because costs associated with other illnesses may be commingled with the lung cancer costs.

The background cost per year for medical services was estimated by Riley et al. to be $2,250 ($3,154 in 1996 dollars), based on the experience of all people over the age of 65 who received Medicare-compensated care. The study excluded those costs that occur during the last year of a person's life. Consequently, the estimated background value may underestimate background costs, especially as age and associated mortality risks increase over the age of 65.

Riley et al. estimated that the total average Medicare payment from diagnosis to death for persons diagnosed with lung cancer was $29,184 in 1990 dollars ($40,908 in 1996 dollars). This value is considerably lower than the estimates obtained from Baker et al. The difference is most likely due to the exclusion of many costs that are not covered by Medicare and the various other factors described above. Due to these limitations, the Riley et al. study is not recommended for a benefits evaluation.

II.5.C Uncertainties and Limitations

As noted periodically in the above discussion, there is uncertainty surrounding various aspects of the analysis. Information concerning some inputs to the analysis was often limited. Although a complete uncertainty analysis is beyond the scope of this work, the significant sources of uncertainty are discussed. Limitations of the scope of the analysis are also discussed.

II.5.C.1 Uncertainties Surrounding Key Inputs to the Analysis

II.5.C.1.1. Analysis of Medical Costs

The cost estimates based on Baker et al. (1989, 1991) have a number of limitations, many of them noted by Baker et al. (1991) and Mor et al. (1990) and Mor (1993). Most of these limitations arise from the use of CMHSF. Medicare data have five limitations that decrease its value for calculating the average lifetime direct medical costs of treating lung cancer. First, Medicare covers medical services for only most persons age 65 and over, disabled persons entitled to Social Security cash benefits for at least 24 months, and most persons with end-stage renal disease. All patients not covered by Medicare are excluded from the database, including all non-disabled women under 65, and women over 65 using private health insurance (Baker et al. 1991).

Given that diagnosis of lung cancer occurs before age 65 in 34 percent of patients (NCI, 1998), the CMHSF excludes a significant number of younger patients. According to Mor et al., treatment for younger women tends to be more intensive (and therefore more costly per unit time) than treatment for older women, though older women tend to have longer hospital stays. Because these differences counteract each other, the

omission of younger women from the analysis is not expected to affect the results substantially. In addition, the majority of senior citizens are enrolled in Medicare (Ibid); differences in medical costs incurred by senior citizens not using Medicare should have little effect on overall cost estimates.[8]

Medicare also does not cover self-administered drugs, intermediate nursing care, long-term nursing care, and some expensive new treatments (such as bone marrow transplants). For some patients these may represent significant percentages of total treatment costs. Most direct medical costs, however, appear to be covered by the CMHSF database and are included in Baker et al.'s analysis. In addition, Baker et al. made adjustments for some cost elements not covered by Medicare (see Section B).

Another drawback is that Baker et al. were not able to identify lung cancer patients in CMHSF whose diagnosis and first course of therapy did not involve hospitalization. In an analysis of Rhode Island lung cancer patients covered by Medicare, Mor et al. determined that a small percentage of lung cancer patients were initially diagnosed without hospitalization, and had substantially lower initial and subsequent treatment costs (Mor et al. 1990). This omission likely causes average treatment costs to be overestimated, though by relatively little.

A fourth drawback is that Baker et al. (1989) provides no information concerning the duration of the maintenance period for lung cancer. The analysis in this chapter assumed that lung cancer survivors incur maintenance care costs for ten years. If the average duration of maintenance care among survivors of lung cancer is shorter (longer) than ten years, then the estimates of the costs incurred by survivors would be biased upward (downward). This bias is less of an issue for nonsurvivors' costs because the great majority of lung cancer nonsurvivors die within the first few years. Because most lung cancer patients (about 88 percent) are ultimately nonsurvivors, the duration of the maintenance period is of somewhat less importance for lung cancer patients than for the 12 percent who ultimately survive the illness.

A fifth drawback is that the data used by Baker are from the period 1974 to 1981. This limitation causes uncertainty regarding changes in treatment methods and costs.

Finally, the reliability of the data contained in the database used by Baker et al. varies. An independent analysis of CMHSF performed in 1977 by the Institute of Medicine of the National Academy of Sciences found that the frequency of discrepancies in principal diagnoses varied among diseases (Baker et al., 1991). It is unclear whether the presence of misnamed

[8] This figure represents those enrolled in Medicare Part A; 95 percent of those enrolled in Medicare Part A choose also to enroll in Medicare Part B.

diagnoses contained in CMHSF potentially increases or decreases the resultant cost estimates.

Overall, despite the limitations described above, Baker's analysis of the CMHSF data represents the most nationally-representative, per-patient lifetime estimate of the direct medical costs of treating lung cancer to date. Their cost estimates are based on sound criteria. Some data limitations underestimate costs and others overestimate costs; the sum of the data limitations therefore decrease the magnitude of error. More of the uncertainties in their analysis appear to underestimate costs, however; the net result is a likely underestimation of actual direct medical costs.

Although there are some uncertainties associated with the estimation of the survival and mortality probabilities used in the calculation of expected medical costs and lost time (discussed below), these uncertainties are likely to be relatively small. As noted in the text, NCI RSRs used to estimate survival and mortality for this analysis are based on the survival experience of a large group of lung cancer patients considered in relation to the survival experience of the general population. Although age-specific RSRs for each year post-diagnosis are not available, the age-specific five-year RSRs provided by NCI (1998) suggest that there is relatively little variation in RSRs across ages at diagnosis for lung cancer patients.

An additional limitation of this analysis is that medical costs incurred as a result of lung cancer, but not considered by Baker et al., may arise as a result of treatment for lung cancer. Secondary cancers and other adverse health effects may occur due to radiation, chemotherapy treatment, and other therapies. These effects may occur substantially after lung cancer treatment has been completed, and can incur added medical costs not considered in this chapter.

Data have not yet been located regarding the average duration of maintenance care. For purposes of this analysis, ten years of follow-up care was assumed to be reasonable due to the severity of the disease and the consequences of lung surgery. This assumption may be revised in the future if data are located.

II.5.C.2 Scope of the Analysis

The analysis in this chapter was confined to direct medical costs by the patient. As noted in Chapter I.1, willingness-to-pay has many other cost elements.

Link to Chapter I.1

The analysis does not include time lost by the patient and his or her family and friends who provide care, pain and suffering on the part of the patient and his or her family and friends, changes in job status among previously employed patients, training for new job skills due to physical limitations, or medical costs incurred after the ten-year maintenance period. These cost elements may comprise a substantial portion of the total cost of lung cancer.